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Real-time Monitoring of our Warfighters Health State:

Presented by
COL Beau Freund
Commander USARIEM
at ATA 2008
Seattle, WA

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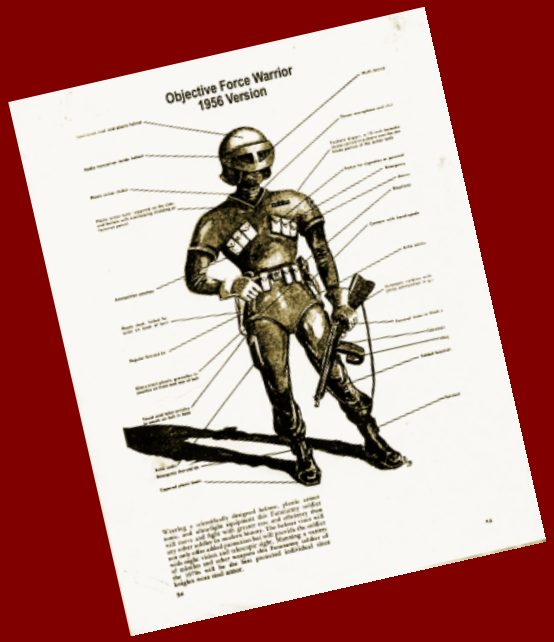
Disclaimer

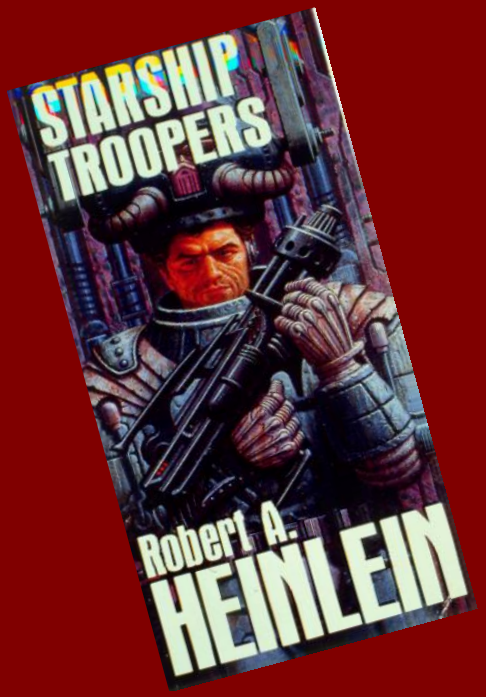
- The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or reflecting the views of the Army or the Department of Defense.

Disclaimer 2

- The idea of monitoring a Warfighter's health state is not new.



Circa 1956



Circa 1959

Background: Why real-time monitoring?

- Situational awareness is limited to the immediate presence of a medic
- No tool to monitor individual/unit health readiness or triage casualties at a distance
- No remote awareness of casualty vital signs
  - Medics attending to Soldiers KIA
    - endangers medics
    - limits resources

Background: Why real-time monitoring?

- Thermal casualties
  - reduce unit readiness
  - can be fatal
- Dehydration
  - ↑ risk thermal casualty
  - ↓ physical & cognitive performance
- Limited Sleep
  - ↓ cognitive performance
  - ↑ preventable accidents

Paramount Considerations

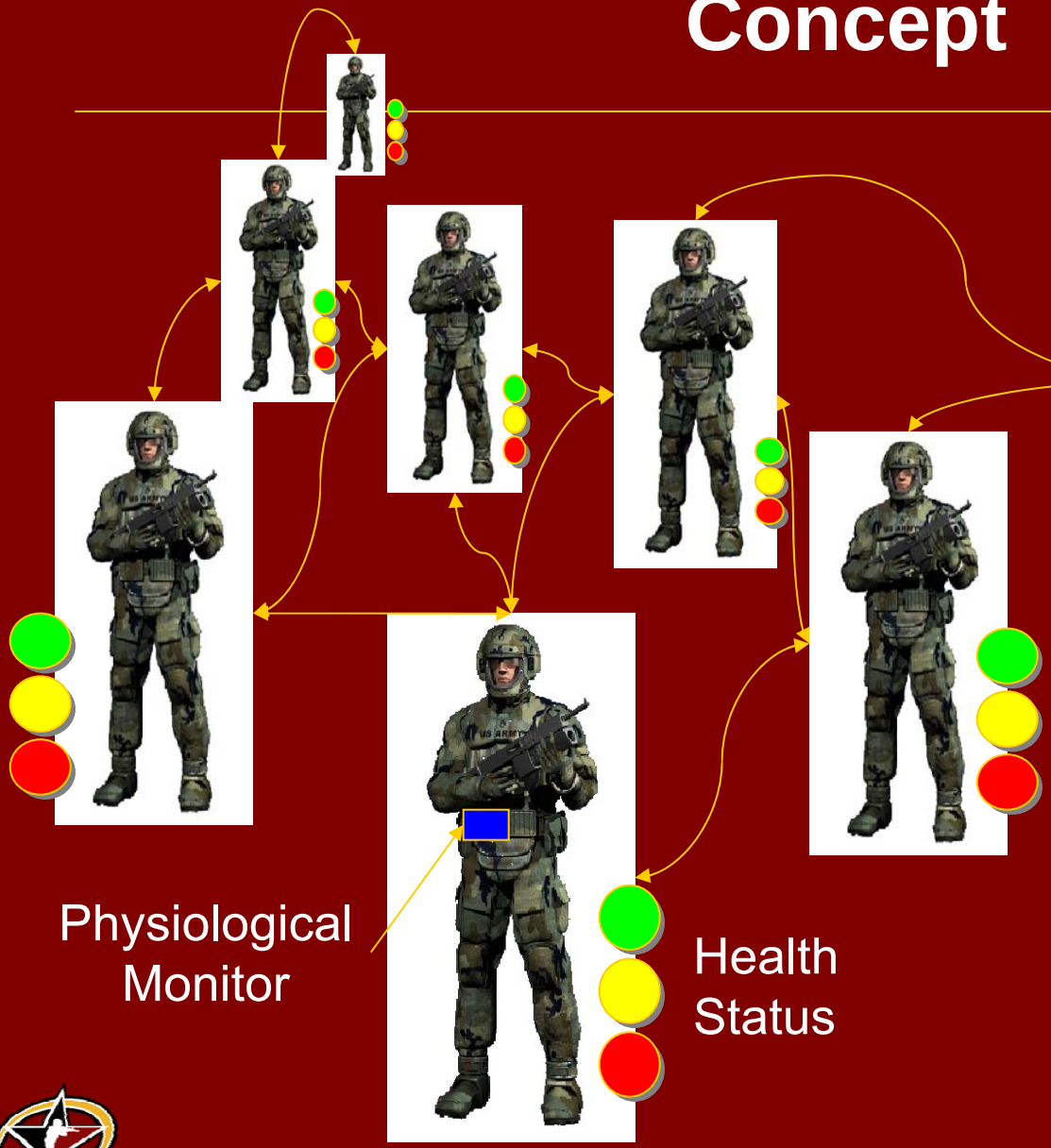
- Minimal Power, Weight, and Cube
- Open Architecture to Facilitate Upgrades
- Block/Spiral Development
- Keep it Small and Simple
- Minimize Logistics Trail
- Economically Reproducible

Decision Assist Tool Complexity

- **No medic eyes on**
- **Hard to test Vital Sign Algorithms**
- **False positives must be very low**
  - **i.e. Don't say someone is dead when they are alive and can be helped**
- **Human device interface is complex**
- **Artifact**

- **Hardware**
  - Is it connected?
  - How is the battery?
  - Did is slip?
  - Proper tension?
  - Was it shot off?
  - Was it properly put on?
- **Activity**
  - Movement / placement
  - Talking
  - Vehicle movement
  - Gun fire
  - Run with load
  - Pack shifting
- **Goop & Goo**
  - Grease / Camouflage
  - Repellents (DEET, promethryn)
  - Sugars
  - Washing / Cleaning
    - Chlorine
    - Detergent

Concept



Physiological Monitor

Health Status

Medic

The GOOD

Technologies & a solution framework have been greatly advanced. Health state monitoring is no longer science fiction.

Maturing Sensors
WPSM Design Principles
WPSM Design Framework
Certification and Lab Testing
Medical Monitoring

The GOOD

Maturing Sensors

- *Sensor Development*
  - *Foster Miller*
    - *Added ECG and Respiration Waveform Capabilities*
  - *Hidalgo System*
    - *Added Core Temperature Capabilities*
  - *Quasar*
    - *Fielding a initial system to Aberdeen Test Center (Jan/Feb 2008)*
  - *Zephyr*
    - *Commercially available system with ECG and Resp. Waveform*

Foster Miller

Hidalgo Equivital

Quasar

Vivometrics Lifeshirt 300S

Zephyr

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The GOOD

Real-Time Monitoring Design Principles

- Modular
- Open
- Extensible
- Personalizable
- Spiral Development
- Initial Capability (IC) “Locked”

The GOOD

Real-Time Monitoring Design Framework

	Sensors	Network	Info. Management	Customers
Current *Real-Time Monitoring*	VSDS BIDS FIM Core Pill Temp Patch	Hardwire Mini Mitter Vital Sense Network Blue Tooth (FFW)	HEALTH HUB State Classifiers: Vital signs, Thermal, Hydration Sleep Performance Models	Land Warrior Future Force Warrior
P3I	•Non-Contact ECG • Cardiac Output • Non Invasive Core Temp. •Cardiac Output	•Inductive • Zigbee • Stealthy • Through Body •Ultra-wide Band	• Movement Classifiers • Metabolic Rate • Individual Models • BIDS Wound Location • BIDS Wound Severity • Triage	• Early Insertion Efforts • SOF • Rangers • CST-WMD • Training Units
Future				

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The GOOD

Real-Time Monitoring: Initial Capability System

BMIS-T

Medic Display

Hub

911 Button
Runs Health state algorithms
Interfaces with the PIC/EIC

FFW Link
→ GPS, Environmental
← Health State Metrics

Vital Sign Detection System (VSDS)

ECG, Respiration, Ambulation, Body Orientation, Skin Temp.

Core Temp

Thermal State

Fluid Intake Monitor

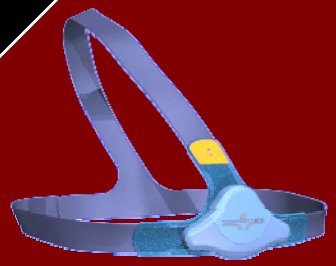
Hydration State

Sleep Watch

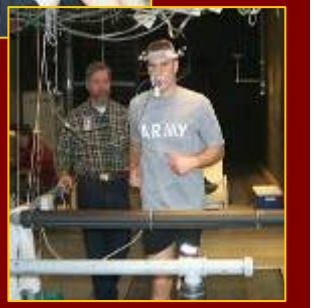
Cognitive/sleep Performance State

The GOOD

Certification and Lab Testing



- **FDA 510K Certified (November 2006):**
  - Heart Rate Monitor
  - Respiration Effort Monitor
  - Welfare Index



- **Lab Validation Testing**
  - February 2006
    - HR +/- 2 bpm
    - RR +/- 3 bpm (for low activity)

- **Human Factors Testing**
  - 2004 early form factor testing
  - Feb & June (2006) Feb (2007)
    - Devices worn during field exercises for 8 hours – 72 Hours
    - Iterative design process to fix comfort and durability issues

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The GOOD

1st CST-WMD Real-Time Medical Monitoring

Methods

1st CST-WMD Enclosed Space Training Event (June 7 & 8, 2007)

- 2 Day Event
- Monitor Environment
- Monitor Physiology
- Display Physiology in Real Time for Use by Physician Assistant

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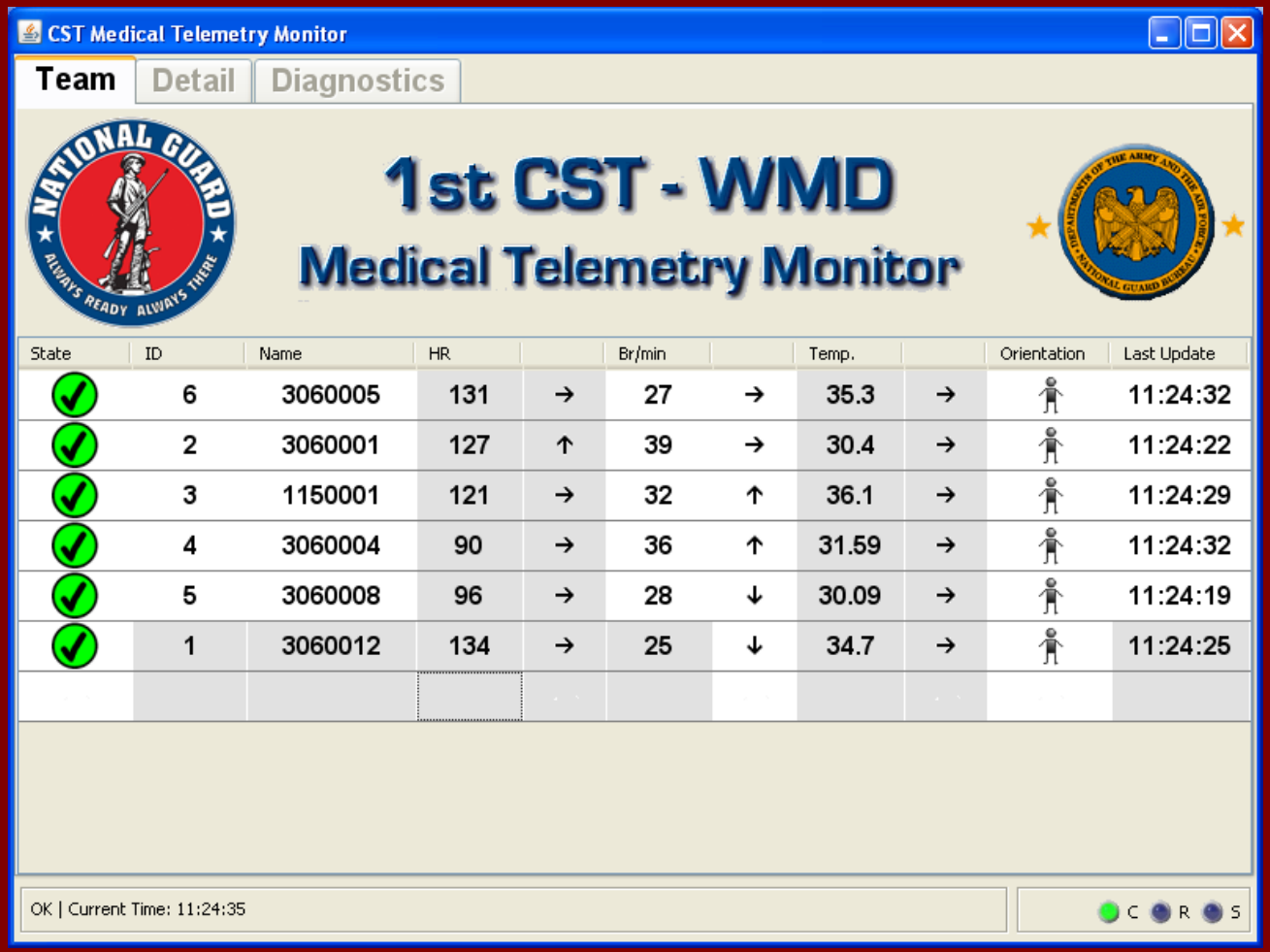
The GOOD

Medical Monitoring Telemetry System – In Action

Results – Physiology, Real Time Display



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The BAD

Unique challenges make the creation and fielding of a product difficult.

Changing Objectives
Changing Requirements
Changing Configurations

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The BAD

Changing Objectives

- **2004 Comprehensive Physiological Status Monitoring System – Integrated into Objective Force Warrior (OFW)**
  - Thermal State, Hydration State, Cognitive State, Vital Sign State, Ballistic Impact Detection
    - Technology Down Select
    - Human Factors form fit design to meet OFW ensemble
    - Integrated algorithms and network
- **2005 Stand Alone WPSM system for Future Force Warrior (FFW)**
  - Intellectual Property and Funding Issue to Integrate Network
  - FDA Issue to integrate algorithms
  - Hydration State requirement dropped
- **2006 Stand Alone Vital Sign Detection System (VSDS)**
  - Change from WPSM network to standard Bluetooth Network
  - Change to new interface specifications
- **2007 FFW Program Ends - Now Integrate to Land Warrior**
  - Hardwired interface required because of security issues on the battlefield
  - Only leaders will have radio systems

Two original ATO's schedules were synchronized.

The FFW ATO was extended but the WPSM ATO was not.

Thus WPSM and FFW schedules became out of sync.

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The BAD

Changing Requirements

VSDS was originally specified with an integrated Ballistic Impact Detection Technology

- Final specification was simplified
  - Only Vital Signs Detection was wanted/affordable

The communication link for health status information was planned as the individual radio

- Land Warrior: current decision is to have radio only on the team leaders

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The BAD

Changing Configuration Timeline

Initial Design	Future Force Warrior (FFW) Design	Land Warrior (LW) Design
Multiple sensors	One sensor	One sensor
Wireless sensor network	Bluetooth wireless sensor connection	Wired sensor connection
No Soldier computer	Soldier computer	Soldier computer and radio only on leaders
No Soldier radio	Soldier radio	Interceptor body armor with no standoff
No body armor	Integrated load carriage and body armor with standoff	Side sensor location
PDA display	Front chest sensor location	

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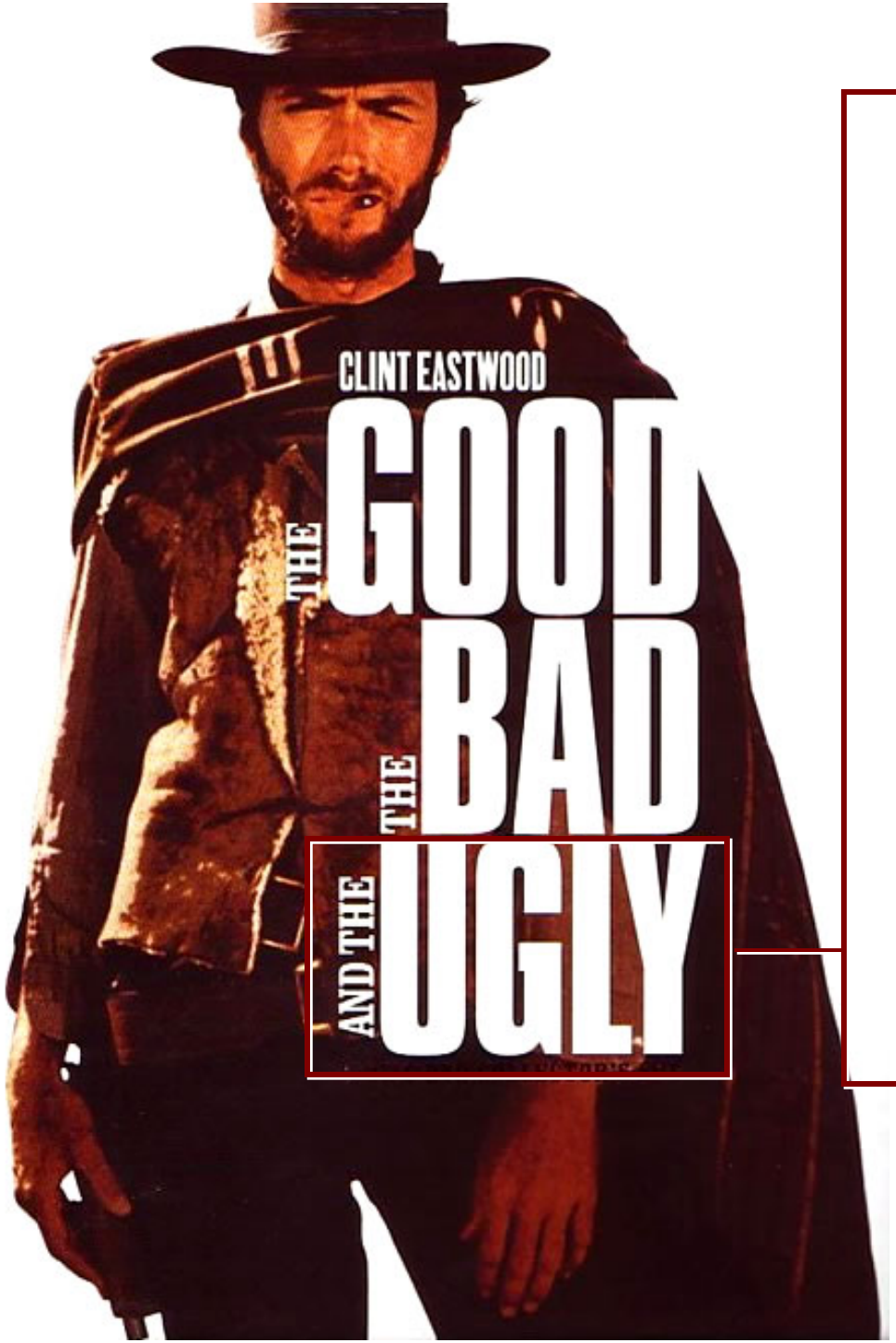

The UGLY

The DOD acquisition process is complex. Redirecting early component work to enable a good fieldable system requires time, effort, and coordination.

Deliberate Capabilities Development process
FFW System of Systems

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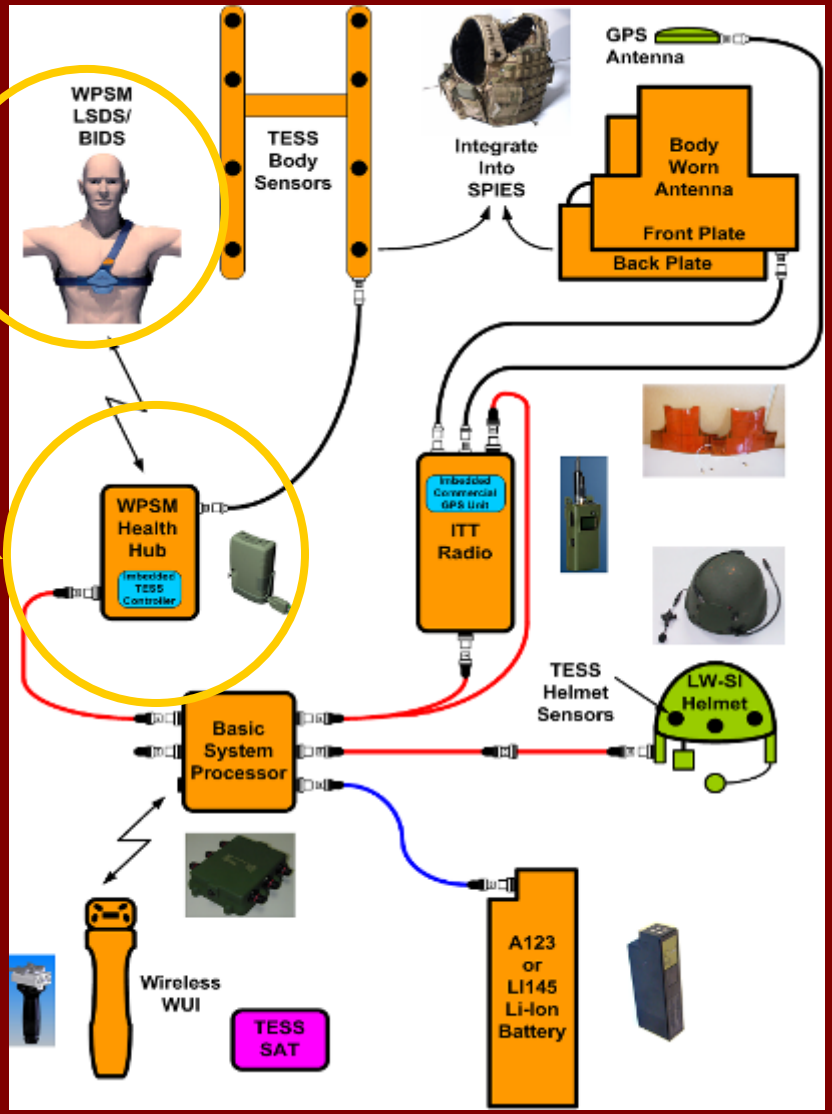
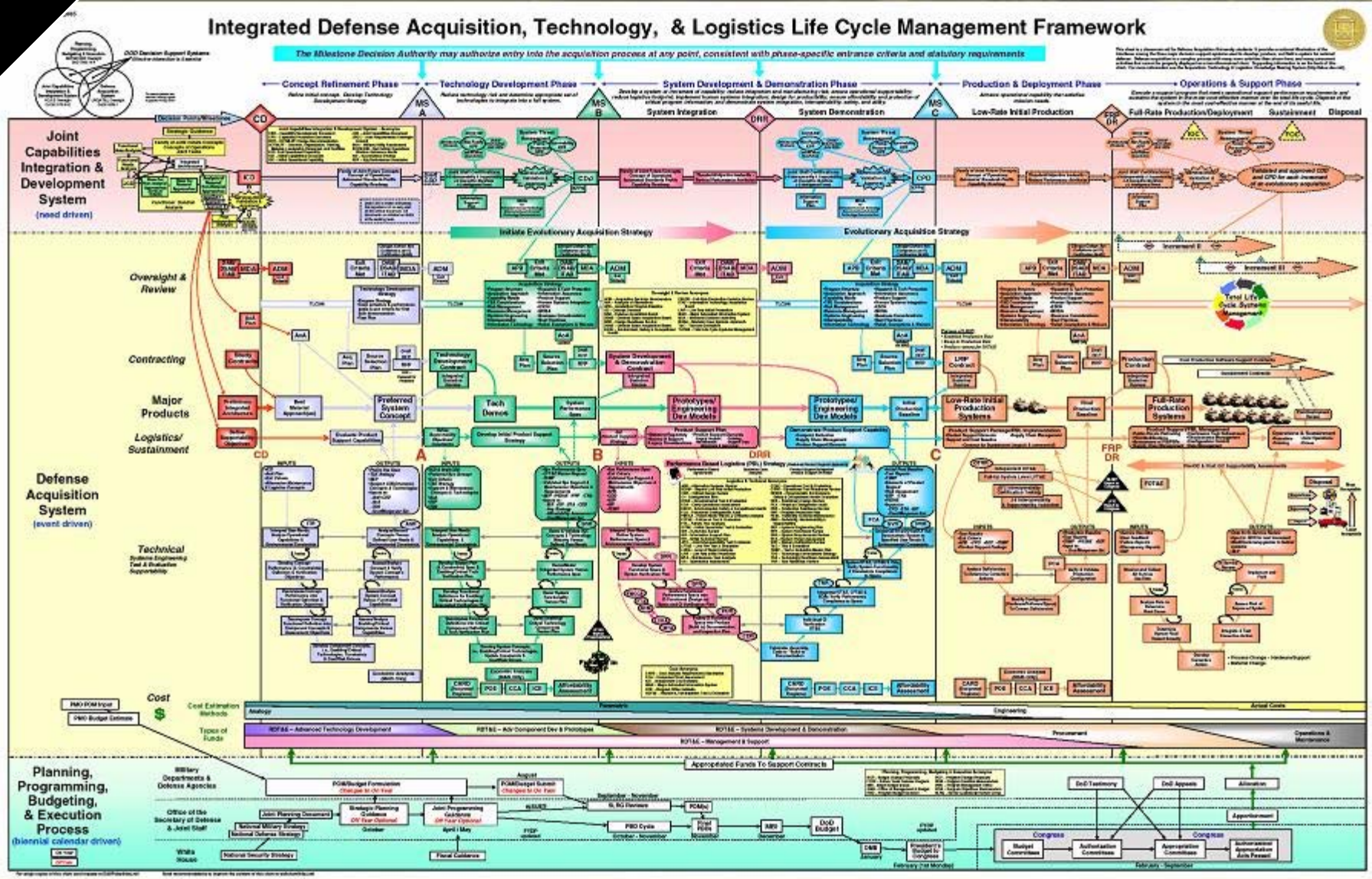
The UGLY

FFW "System of Systems" (SOS)



The UGLY

The Deliberate Capabilities Development Process (JCIDS)



Summary

- Despite current challenges of fielding integrated solutions the future is very bright.
- Significant advances in technologies and supporting firmware/software will continue to be made
- Academia, industry and the Defense Department will share in the further development and exploration of these technologies.
- The potential of future applications to home health care, safety monitoring, professional & recreational athletes, research and the Department of Defense are tremendously exciting.

Summary

- Lab on a chip
- The individual “dashboard”
- Personalized medicine
- Remote “office calls”
- Affordable, integrated solutions
- Performance optimization based on individual’s physiology
- Previously unattainable real-time data sets.

Summary

50 years ago Starship Troopers was written as science fiction

What of today's science fiction will be possible in 2059?

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